COMPOSITE PLY STRUCTURE FOR TIRES AND METHOD OF MANUFACTURE

Technical Field

This invention relates to tires, generally and more specifically, composite ply structures and methods of manufacturing the composite ply structure including at least one primary ply of inextensible radial extending cords, most preferably of fine diameter steel cords primarily for use in passenger pneumatic or light truck tires, including, not limited to, runflat type tires.

Related Patents

This patent application relates to co-pending U.S. patent application Serial No. 09/077,646 (attorney Docket No. DN1998-047-PCT).

Background of the Invention

The use of radial steel cords in tires is well known in the tire art. Earthmover and commercial truck tires have used steel corded tires for years.

As the use of steel cords is attempted in passenger tires some common problems of how to consistently make a ply turnup of a steel cord reinforced ply must be resolved.

Historically one must first ask the question of whether or not a ply turnup is even needed.

In 1921, Charles Miller in U.S. Patent No. 1,393,952 taught that plies could be securely anchored to the beads by means of fabric strips having crossed strands relative to the ply cords without any of the plies actually wrapping around the bead core. Miller's tires showed that as few as four plies were possible, a breakthrough for the tires of that era.

In 1942, S. M. Elliott in U.S. Patent No. 2,430,560 reported that farm tires could be made with greater elastic deformation if the bead wrapping fabric strips did not even contact the body plies. A radical departure from what was otherwise accepted practice.

In 1968, Fred Kovac and Grover Rye of The Goodyear Tire & Rubber Company patented a bias tire leaving an outer ply having giant cords of 0.37 inches or greater. This outer ply comprised two parts, a bias body ply and a pair of radial bead plies. The edges of the bead plies overlapped the edges of the body plies and are sandwiched between them. Kovac, et al indicated that the body ply may be of wire and the bead plies may be reinforced with fabric or filament. Kovac pointedly notes that if giant cords are used in the carcass, the plies containing them are so stiff that it is difficult for the tire builder to turn them around the beads. Thus, he recommended that the edges of the stiffer plies stop short of turning under the beads and bead plies of softer fabric are turned under the beads with their edges overlapping the edges of the stiffer plies.

Powers, et al of The Firestone Tire & Rubber Company taught a radial ply pneumatic tire having one or more body plies containing radially directed inextensible cords with the ply ends terminating on the same side of the bead bundle as the ply. The tire further had a bead connector ply containing radial, inextensible reinforcing cords which is wrapped about the bead bundle. Powers, et al noted that a prior art British Patent No. 990,524 disclosed a radial ply body and a radial ply bead wrap, the cords of the body ply being rayon cords and the bead wrap being steel cord reinforced. Powers noted that the differences in modulus resulted in the cords not acting together as if they were one ply, whereas his all-inextensible cord design did act as one ply. Powers taught that the body ply and the bead connecting ply, where they are contiguous to one another, must be at least 20% and not greater than 50% of the peripheral distance of the body ply as measured from the midpoint of the bead bundle along the body ply to the point on the body ply where the edges of the tread ply are located. Powers suggest glass, steel or Kevlar™ cords could be used. The Powers, et al test tire was a 11-22.5 truck tire employing 1x4+6x4x.175+1x.15 radial cords of steel wire of a cable construction having 14 ends per inch. Similarly, the bead connector used the same steel wire construction. These truck tires carry a high operating inflation pressure of about 100 psi and the Powers et al patent demonstrated a potentially feasible concept although no known commercialization of such a truck tire had occurred.

In 1995, Ahmad, et al disclosed a pneumatic tire having a discontinuous outer carcass ply. Ahmad, et al disclosed a full radially inner ply with a conventional turnup end and a discontinuous outer carcass ply that extended from under the belt edges to the bead, the outer ply being contiguously in contact with the outer ply.

EPO Publication 822195A2 discloses a Runflat Tire and Method which shows a runflat tire having multiple radial plies wherein at least one ply is wrapped about the bead and has a turnup, the remaining plies simply terminate near the bead. The bead area concept appears similar to the prior art solutions disclosed in Ahmad with the exception that the plies are spaced by fillers or inserts, a common feature of runflat tires.

The present invention provides a novel way of creating a composite ply structure in a tire. The tire can be a radial ply pneumatic tire including the type known as runflat tires.

Brief Description of Drawings

FIGURE 1 is a cross-sectional view of the tire according to the invention.

FIGURE 2 is an enlarged fragmentary view of one sidewall portion of the tire of FIGURE 1.

FIGURE 3 is a cross-sectional view of an alternative embodiment tire according to the invention, the tire being a runflat tire.

FIGURE 4 is an enlarged fragmentary view of the sidewall portion of the tire of FIGURE 3.

FIGURE 5 is a perspective view of the composite ply shown on a building drum being fabricated employing a first method of assembly. FIGURE 5A is a cross-sectional view of the carcass made to the first method.

FIGURE 6 is a perspective view of the composite ply shown being fabricated in a preferred alternative method. FIGURE 6A is a cross-sectional view of the carcass made to the preferred alternative method.

FIGURE 7A, 7B, and 7C are schematic views of the runflat tire carcass of FIGURE 4 being made according to the method of FIGURE 6.

FIGURE 8 is a cross-sectional view of a second alternative embodiment runflat tire.

FIGURE 9 is a cross-sectional view of a third alternative embodiment runflat tire.

Summary of Invention

A composite ply structure (40) as an intermediate article of manufacture is disclosed. The composite ply structure (40) is for use as a carcass ply for a tire (10).

The composite ply structure (40) has a primary ply (40A) reinforced by cords (41), the cords (41) being encapsulated in unvulcanized rubber (44), and a pair of ply extensions (40B) reinforced by flexible cords (43), the flexible cords (43) being encapsulated in unvulcanized rubber (44).

The ply extensions (40B) each have an end (33) overlappingly joined to the primary ply (40A) along the longitudinal length of the primary ply (40A). One ply extension (40B) is joined at a first end (45) of the primary ply (40A) and the other ply extension (40B) is joined at a second end (46) of the primary ply (40A).

The composite ply (40) has a joint interface (70) between the overlapping ply extensions (40B) and the primary ply (40A). The joint interface (70) is at least surface precured sufficient to prevent slippage of the ply extensions (40B) relative to the primary ply (40A) during subsequent shaping and curing of the carcass. Preferably, the overlapping joint interface (70) has at least one centimeter of width.

The primary ply (40A) has the cords (41) oriented radially in the range of 65° to 90° relative to the ply length; whereas, the ply extensions (40B) can be oriented in the radial ply range of 65° to 90° or alternatively can be oriented in a bias ply range of 35° to 65° relative the ply length.

The method of preforming a composite ply (40) has the steps of cutting to a predetermined width a primary ply (40A) reinforced with parallel cords (41) encapsulated in unvulcanized rubber (44), the width extending between a first end (45) and a second end (46);

applying a pair of ply extensions (40B) of predetermined widths (W_B), one ply extension (40B) being overlappingly joined to each first and second ends (45,46) each ply extension (40B) being reinforced with parallel cords (43) encapsulated in unvulcanized rubber (44); precuring the overlappingly-joined ply extension (40B) to the primary ply locally along the adjoining overlapping joint interface (70) surfaces, thereby forming a composite ply (40) having a predetermined total width (W_T), the composite ply (40) being unvulcanized except at the overlapping joints (70) between the ends (45 or 46) of the primary ply (40A) and the ends (33) of the ply extensions (40B).

The preferred method includes the steps of induction precuring the joint (70) along the mating surfaces by activating an induction heat coil creating an energy field locally thereby rapidly heating the cords 41 which are preferably metallic in the area of the joint interface (70).

Alternatively, the method may include the steps of applying an adhesive coating (80) to the adjoining overlapping surfaces prior to curing the joint; wherein the adhesive coating (80) has induction heat sensitive material (82) and; wherein activation of an induction field of energy along the overlapping joints (70) thereby heats the adhesive after a predetermined time sufficient to at least surface precure the joints (70). This method may further include the step of applying a force to the induction-heated joints to stitch the joints (70). This method is considered less desirable than a direct induction curing without solvents, adhesives or other bonding materials, however, when no metallic cords are used, it is possible the use of a solvent becomes more desirable.

Definitions

"Aspect Ratio" means the ratio of its section height to its section width.

"Axial" and "axially" means the lines or directions that are parallel to the axis of rotation of the tire.

"Bead" or "Bead Core" means generally that part of the tire comprising an annular tensile member, the radially inner beads are associated with holding the tire to the rim being wrapped by ply cords and shaped, with or without other reinforcement elements such as flippers, chippers, apexes or fillers, toe guards and chafers.

"Belt Structure" or "Reinforcing Belts" means at least two annular layers or plies of parallel cords, woven or unwoven, underlying the tread, unanchored to the bead, and having both left and right cord angles in the range from 17° to 27° with respect to the equatorial plane of the tire.

"Circumferential" means lines or directions extending along the perimeter of the surface of the annular tread perpendicular to the axial direction.

"Carcass" means the tire structure apart from the belt structure, tread, undertread, over

the plies, but including the beads.

"Casing" means the carcass, belt structure, beads, sidewalls and all other components of the tire excepting the tread and undertread.

"Chafers" refers to narrow strips of material placed around the outside of the bead to protect cord plies from the rim, distribute flexing above the rim.

"Cord" means one of the reinforcement strands of which the plies in the tire are comprised.

"Equatorial Plane (EP)" means the plane perpendicular to the tire's axis of rotation and passing through the center of its tread.

"Footprint" means the contact patch or area of contact of the tire tread with a flat surface at zero speed and under normal load and pressure.

"Innerliner" means the layer or layers of elastomer or other material that form the inside surface of a tubeless tire and that contain the inflating fluid within the tire.

"Normal Inflation Pressure" means the specific design inflation pressure and load assigned by the appropriate standards organization for the service condition for the tire.

"Normal Load" means the specific design inflation pressure and load assigned by the appropriate standards organization for the service condition for the tire.

"Ply" means a layer of rubber-coated parallel cords.

"Radial" and "radially" mean directions radially toward or away from the axis of rotation of the tire.

"Radial Ply Tire" means a belted or circumferentially restricted pneumatic tire in which at least one ply has cords which extend from bead to bead are laid at cord angles between 65° and 90° with respect to the equatorial plane of the tire.

"Section Height" means the radial distance from the nominal rim diameter to the outer diameter of the tire at its equatorial plane.

"Section Width" means the maximum linear distance parallel to the axis of the tire and between the exterior of its sidewalls, when and after it has been inflated at normal pressure for 24 hours, but unloaded, excluding elevations of the sidewalls due to labeling, decoration or protective bands.

"Shoulder" means the upper portion of sidewall just below the tread edge.

"Sidewall" means that portion of a tire between the tread and the bead.

"Tread Width" means the arc length of the tread surface in the axial direction, that is, in a plane parallel to the axis of rotation of the tire.

Detailed Description of the Invention

The reference numerals as depicted in the drawings are the same as those referred to in the specification. For purposes of this application, the various embodiments illustrated in the figures each use the same reference numeral for similar components. The structures employed basically the same components with variations in location or quantity thereby giving rise to the alternative constructions in which the inventive concept can be practiced. The tire (10) according to the present invention employs a unique sidewall structure (20). The tires (10), as illustrated in FIGURES. 1 and 2, are radial passenger or light truck tires; the tires (10) are provided with a grounding gauging tread portion (12) which terminates in the shoulder portions at the lateral edges (14, 16) of the tread (12) respectively. A pair of sidewall portions (20) extend from the lateral edges (14, 16), respectively, and terminates in a pair of bead portions (22), each having an annular inextensible bead core (26) respectively. The tire (10) is further provided with a carcass reinforcing structure (30) which extends from the bead portion (22) through one sidewall portion (20), tread portion (12), the opposite sidewall portion (20) to bead portion (22). The carcass structure (30) has at least one composite ply structure (40) having turnup ends (32) wrapped about the bead cores (26) respectively. The tire (10) may include a conventional innerliner (35) forming the innerperipheral surface of the tire (10) if the tire is to be of the tubeless type. Placed circumferentially about the radially outer surface of the carcass reinforcing structure (30) beneath the tread portion (12) is a tread reinforcing belt structure (36). In the particular embodiment illustrated, belt structure (36) comprises two cut belt plies (50, 51) and the cords of the belt plies (50, 51) are oriented at an angle of about 23° with respect to the mid-circumferential centerplane of the tire. The cords of the belt ply (50) are disposed in an opposite direction relative to the mid-circumferential centerplane and from that of the cords of belt ply (51). However, the belt structure (36) may comprise any number of belt plies of any desired configuration and the cords may be disposed at any desired angle. The belt structure (36) provides lateral stiffness across the belt width so as to minimize lifting of the tread from the road surface during operation of the tire in the uninflated state. In the embodiments illustrated, this is accomplished by making the cords of the belt plies (50, 51) of preferably steel and more preferably of a steel cable construction.

The carcass reinforcing structure (30) of the preferred embodiment tire (10) as shown in FIGURE 1 comprises at least one composite ply structure (40). The at least one composite ply structure (40) has one primary ply (40A) extending from bead portion (22) to bead portion (22). The primary ply preferably has one layer of parallel cords (41); the cords (41) of the primary ply are oriented at an angle of at least 75° with respect to the mid-circumferential centerplane of the tire. Overlapping and joined to the primary ply (40A) is a ply extension (40B) having cords (43). The cords (43) of the ply extension (40B) are oriented at an angle of at least 75° with

respect to the mid-circumferential centerplane of the tire. In the particular embodiment illustrated, the cords (41, 43) are oriented at an angle of about 90° with respect to the mid-circumferential centerplane. The cords (41) of the primary ply (40A) of the at least one composite ply structure (40) are preferably made of an inextensible material such as steel, Kevlar™ or glass. Whereas, the cords (43) may be made of any material normally used for cord reinforcement of rubber articles, for example and not by way of limitation, aramid, rayon, nylon, and polyester.

The primary ply (40A) has cords (41) that are preferably substantially inextensible, the cords are synthetic or metal, more preferably metal, most preferably steel of high tensile strength. The cords (41) have modulus X. In the case of steel cords (41), the modulus is greater than 150 GPa. One way of achieving such strength is by merging the proper process and alloys as disclosed in U.S. Patent Nos. 4,960,473 and 5,066,455, which are hereby incorporated by reference in its entirety herein, with a steel rod microalloyed with one or more of the following elements: Ni, Fe, Cr, Nb, Si, Mo, Mn, Cu, Co, V and B. The preferred chemistry is listed below in weight percentages:

C	07 to 1.0
Mn	0.30 to 0.05
Si	0.10 to 0.3
Cr	0 to 0.4
V	0 to 0.1
Cu	0 to 0.5
Ni	0 to 0.5
Co	0 to 0.1

The balance being iron and residuals

The resulting rod is then drawn to the appropriate tensile strength.

The cords (41) for use in the non-runflat tire carcass (30) of FIGURES 1 and 2 may comprise from one (monofilament) to multiple filaments. The number of total filaments in the cord (41) may range from 1 to 13. Preferably, the number of filaments per cord ranges from 6 to 7. The individual diameter (D) of each filament generally ranges from .10 to .30 mm, for each filament having at least a tensile strength of 2000 MPa to 5000 MPa, preferably at least 3000 MPa.

Another critical property of the steel cord (41) is that the total elongation for each filament in the cord must be at least 2 percent over a gauge length of 25 centimeters. Total elongation is measured according to ASTM A370-92. Preferably, the total elongation of the cord ranges from about 2 percent to 4 percent. A particularly preferred total elongation ranges from about 2.2 to about 3.0 percent.

The torsion values for the steel for the filament used in the cord should be at least 20 turns with a gauge length of 200 times the diameter of the wire. Generally, the torsion value ranges from about 20 to about 100 turns. Preferably, the torsion values range from about 30 to about 80 turns with a range of from about 35 to 65 being particularly preferred. The torsion values are determined according to ASTM Test Method E 558-83 with test lengths of 200 times the diameter of the wire.

There are a number of specific metallic cord (41) constructions for use in the primary ply (40A). Representative examples of specific cord constructions include 1 x, 2 x, 3 x, 4 x, 5 x, 6 x, 7 x, 8 x, 11 x, 12 x, 1 + 2, 1+ 4, 1 + 5, 1 + 6, 1 + 7, 1 + 8, 2 + 1, 3 + 1, 5 + l, 6 + 1, 11 + 1, 12 + l, 2 + 7, 2 + 7 + 1, 3 + 9, 1 + 5 + 1 and 1 + 6 + 1 or 3 + 9 + 1, the outer wrap filament may have a tensile strength of 2500 MPa or greater based on a filament diameter of .15 mm. The most preferred cord constructions including filament diameters are 3 x .18, 1 + 5 x .18, 1 + 6 x .18, 2 + 7 x .l8, 2 + 7 x .18 x 1 x .15, 3 + 9 x .18 + 1 x .15, 3 + 9 x .18, 3 x .20 + 9 x .18 and 3 x .20 + 9 x .18 + 1 x .l5. The above cord designations are understandable to those skilled in the art. For example, designation such as 2 x, 3 x, 4 x, and 5 x mean a bunch of filaments; ie, two filaments, three filaments, four filaments and the like. Designation such a 1 + 2 and 1 + 4 indicate, for example, a single filament wrapped by two or four filaments.

The primary ply (40A) has a layer of the above described steel cords arranged so as to have from about 5 to about 100 ends per inch ($\approx$2 to 39 ends per cm) when measured at the equatorial plane of the tire. Preferably, the layer of cords are arranged so as to have about 7 to about 60 ends per inch ($\approx$2.7 to 24 ends per cm) at the equatorial plane. The above calculations for ends per inch are based upon the range of diameters for the cord, strength of the cord and the practical strength requirement for the ply. For example, the high number of ends per inch would include the use of a lower diameter cord for a given strength versus a lower number of ends per inch for a higher diameter wire for the same strength. In the alternative, if one elects to use a cord of a given diameter, one may have to use more or less ends per inch depending on the strength of the cord.

The metallic cords (41) of the composite ply (40) are oriented such that the tire (10) according to the present invention is what is commonly referred to as a radial.

The steel cord of the ply intersect the equatorial plane (EP) of the tire at an angle in the range of from 75° to 105°. Preferably, the steel cords intersect at an angle of from 82° to 98°. The preferred range is from 89° to 91°.

The composite ply (40) has a plurality of fine diameter cords (41) with the cord diameter (C) less than 1.2 mm. The cord (41) can be any of the before mentioned cords including but not limited to 1+5x.18 mm or 3x.18 mm or a monofilament wire having a diameter of about 0.25

mm, preferably 0.175 mm. It is considered desirable that these cords (41) have filaments having a minimum tensile strength of at least 2500 MPa and over 2.0 percent elongation, preferably about 4000 MPa and over 2.5 percent elongation.

As further illustrated in FIGURE 2, the at least one composite ply structure (40) has a pair of ply extensions (40B), each having a radially inner end (33) and a turnup end (32) respectively, which wraps about the bead core (26). The ply extension (40B) are in proximity to the bead core (26) and terminate radially above and axially inward of the bead core (26) with the end (33) overlappingly engaging the terminal ends (75, 76) of the primary ply (40A). In the preferred embodiment, the axially outer turnup ends (32) are located within 20% of the section height (SH) of the tire from the radial location (h) of the maximum section width, most preferably terminating at the radial location (h) of the maximum section width. As shown the turnup ends (32) terminate radially a distance (E) above the nominal rim diameter of the tire in proximity to the radial location (h) of the maximum section width of the tire. As further illustrated in FIGURES 1 and 2, the bead portions (22) of the tire (10) each have an annular substantially inextensible bead core (26). The bead cores each have a flat base surface (27) defined by an imaginary surface tangent to the radially innermost surface of the bead wires. The flat base surface (27) has a pair of edges (28, 29), and a bead width "BW" between the edges. Preferably the bead core (26) may further include a flat radially outer surface (31) extending between first and second surfaces (23, 25) respectively. The radially outer surface (31) has a maximum height (BH), the height (BH) is less than the width of the base (BW). The cross-section defined by the surfaces (23, 25, 27 and 31) preferably are in the form of a substantially rectangular or trapezoidal cross-section.

The bead cores preferably are constructed of a single or monofilament steel wire continuously wrapped. In a preferred embodiment, 0.050 inch diameter are wires wrapped in layers radially inner to radially outer of 7, 8, 7, 6 wires, respectively. The flat base surfaces of the bead cores (26) are preferably inclined relative to the axis of rotation, and the bottom of the multi-portion of the bead is similarly inclined, the preferred inclination being about 10° relative to the axis of rotation preferably about 10.5°. This inclination of the bead base assists in sealing the tire and is about twice the inclination of the bead seat flange of a conventional rim and is believed to facilitate assembly and assists in retaining the beads seated to the rim.

Located within the bead region (22) and the radially innerportion of the sidewall portions (20) are high modulus elastomeric apex fillers (48) disposed between the carcass reinforcing structure (30) and the turnup ends (32) respectively. The elastomeric fillers (48) extend from the radially outer portion of the bead cores (26) respectively, up into the sidewall portion gradually decreasing in cross-sectional width. The elastomeric fillers (48) terminate at a radially outer end

at a distance (G) from the nominal rim diameter (NRD) of at least 25% of the section height (SH) of the tire.

In a preferred embodiment of the invention, the ply extensions (40B) have parallel radially extending cords (43). Alternatively, the ply extensions (40B) could have cords (43) oriented at a bias angle relative to the radial direction. The amount of and direction of orientation could range at an included angle relative to the radial direction in the range from 25° to 75°, preferably 45° or less. It is believed the cord reinforcement of the ply extension (40B) utilizing bias angled cords can be used to improve the handling characteristics of the tire when the tire is uninflated.

With reference to FIGURES 3 and 4, the carcass reinforcing structure (30) of the preferred embodiment runflat tire (10) as shown in FIGURE 3 comprises at least two reinforcing ply structures (38, 40). In the particular embodiment illustrated there is provided a radially inner ply reinforcing structure (38) and a radially outer composite ply reinforcing structure (40), each ply structure (38, 40) preferably has one layer of parallel cords extending radially from bead portion (22) to bead portion (22). The second ply reinforcing structure (38) wraps around the composite ply structure (40) and has a turnup end (34) extending radially outwardly. The second ply structure (38) preferably has synthetic cords (45) of nylon or rayon, aramid or polyester material. Whereas, the composite ply (40) is precisely as earlier defined having a primary ply (40A) extending from bead to bead and having inextensible cords (41) and an overlapping ply extension (40B) having a synthetic cord (43) wrapping about the bead (26) and having a turnup end (32). Radially inward of the second ply reinforcing structure (38) is an elastomeric insert (42) interposed between an innerliner (35) and the ply (38). Between the ply (38) and the primary ply (40A) of the composite ply (40) is an elastomeric insert (46). The cords (41) of the primary ply (40A) are preferably inextensible and made of steel; whereas, the cords (43) of the ply extension (40B) are preferably synthetic and made of a similar material to that of the second ply (38). The runflat tire has an unloaded and inflated section height of (SH). When normally inflated, but statically loaded, the tire deflects yielding a loaded height of about 75% or less of (SH). When the tire is uninflated and similarly statically loaded, the tires section height is 35% or greater of (SH). This class of tires generally have thicker sidewalls as shown in FIGURES 3, 4, 8 and 9. Such tires can employ a composite ply having inextensible cords (41) having filaments of a diameter from 0.05 to 0.5 mm, preferably 0.25 to 0.4 mm. Such cords (41) are preferably metallic, made of steel, but are not limited to very high tensile steel cords of pneumatic tires without runflat capability. This is made possible because the thickened sidewalls limit the flexure fatigue or bending fatigue of the cords (41) enabling more rigid cords to be employed. This has the advantage of increasing the tires load carrying capability while

lowering the tires cost. This construction has many similarities to a co-pending application entitled "RUNFLAT TIRE WITH IMPROVED CARCASS", Serial No. 08/865,489 filed on May 29, 1997, which is incorporated in its entirety herein by reference. In that application, it was pointed out that the bending modulus of the sidewall structure could be moved to be substantially adjacent to the inextensible cords (41) of the ply structure (40). By attaching an overlapping synthetic cord (43) as a ply extension (40B), which wraps around the bead portion, the tire engineer is now able to tune or adjust the performance of the tire so that in the bead area (22) the substantially more compliant synthetic material is effectively wrapped around the beads providing for easier assembly and an ability to adjust the ride performance of the vehicle by raising or lowering the transition between extensible and inextensible ply cords. By doing that, the engineer is able to adjust the radial location of the overlap between the extensible and inextensible cords so that the tire can act more like a composite having primarily synthetic cords in the lower bead region or he can adjust the stiffness by lowering the inextensible cords to adjacent the bead area to increase the stiffness of the bead portion.

With reference to FIGURE 5, there is shown a perspective view of the composite ply (40) shown on a building drum (5). The composite ply (40) has the ply extensions (40B) pre-attached to the primary ply component (40A). The bead cores (26) are then placed over the ply extensions (40B) to an area approximately axially adjacent the primary ply (40A) on each side of the tire (10) as shown. As the tire carcass is inflated, the ply extensions (40B) hold the primary ply (40A) near the proximate location relative to the bead core (26). FIGURE 5A shows the cross-sectional view of the features described above.

FIGURE 6 is a perspective view of the composite ply (40) shown being fabricated.

As shown, the primary ply (40A) has been cut to a predetermined width W_A. The width W_A extends transversely across the primary ply (40A) from a first end (45) to a second end (46) substantially perpendicular to the longitudinal length of the primary ply (40A). In one preferred embodiment, the ends (45, 46) are spaced to lie adjacent to but inward of the bead cores (26) when the ply (40) is applied to a tire building drum (5).

The ply extensions (40B) preferably overlap the ends (45,46) a minimum distance of 1 cm. The ply extensions (40B) may be joined to be radially below or inward of the primary ply (40A). In such a case, the first ends (45) and second ends (46) of the primary ply (40A) are interposed between the bead cores (26) or apex filler (48) and the ply extensions (40B). Alternatively, the ply extensions (40B) can lie radially above the primary ply (40A) such that the first ends (45) and second ends (46) lie radially inward of the ply extensions (40B).

An important feature of the present invention is that the adjoining joint surfaces (70) of the ply extension (40B) and the primary ply (40A) in the region of the joint overlap should be at

least surface precured. This at least surface precuring locally in the joint (70) area of the overlapping portions insures that the ends (45,46) of the primary ply (40A) remain securely fixed at a known location relative to the bead cores (26). It has been determined that when the surfaces at the joint interface (70) are unvulcanized, they will slip during the molding process. As the rubber softens and begins to liquefy during molding, the joint (70) looses its ability to hold the ply ends (45,46). Typically, one end (45 or 46) will soften and slip before the other end. Once the slippage occurs, the cord tension of the tire is relaxed. Accordingly, the other side has no tension to force an equal slippage. The net result is the end (45) may be higher or lower than the end (46) and the distance between ends (45) and (33) is not equal to the distance between ends (46) and (33). This changes the tire's performance and handling characteristics in a random and less than predictable manner. This type of cord path slippage is commonly referred to as a "non-uniformity". Generally speaking, non-uniformities are preferably avoided.

The present invention solves the problem of cord slippage in a unique manner. The adjoining and overlapping surfaces at the joint (70) are at least surface precured. This locks the ply cords (41, 43) together at their respective ends (33, 45, 46) so that slippage of cords (41) relative to a ply extension cords (43) is eliminated. This insures that when the tire is built on a building drum, the bead cores (26) and the drum (5) secure the location of the ply path between the bead cores (26). Thus, when the tire (10) is toroidally-shaped, the ply path is fixed without a slippage of the joint (70). Since the joint (70) does not slip, the ends (45,46) remain equally spaced above the bead cores (26). In the present application, the primary ply cords (41) are substantially inextensible while the cords (43) of the ply extension (40B) are flexible and substantially extensible relative to the primary ply cords (41). This feature coupled with the cured joints (70) insures that the tension in the cords (41) is transferred to the ply extensions (40B) equally on each side of the tire (10). This means that all stretching occurs in the ply extension cords (43) generally equally. This feature enables the tire (10) to be manufactured repeatedly and uniformly in mass production.

In one method of surface precuring the joint (70), the steps of locally curing the joint (70) is accomplished by applying an adhesive (80) to the adjoining surfaces. Once coated with the adhesive, the joint is heated curing the mating surfaces. Care is taken to limit the curing of the ply (40) to the area occupying the overlapping portions of the joints (70) leaving the remaining rubber surfaces unvulcanized.

Preferably, the adhesive (80) may have induction-sensitive material (82) included in the formulation. Thus, when the joints (70) treated with the adhesive (80) are exposed to an induction heating energy field, the sensitive material (82) is activated giving rise to rapid heating and curing of the surfaces of the joint (70), the induction coil not illustrated.

Once cured or heat activated, the joints (70) are forced together creating a cured joint (70). The forcing together is commonly referred to as "stitching".

The ply extensions (40B), when applied to the primary ply (40A), are presumed to have predetermined width (W_B). The overlapping of the primary ply (40A) and the two ply extensions (40B) yield a composite ply (40) having a total width of $W_T=W_A+2W_B-2X$, where X equals the width of the overlap at each joint (70). The total width (W_T) of the composite ply structure (40) includes the distance between the bead cores (26) and the two ply turnups (32).

It is accordingly appreciated that the tire engineer can vary the location of the ends (45,46) to tune the tire's performance.

Another equally important tire tuning feature is the ability to select optimal cord angles of the ply extensions (40B) to enhance handling. Thus, bias-angled cords (43) in the ply extensions (40B) can create improved tire handling.

As can be seen from both FIGURES 5 and 6, the resulting constructions are fundamentally the same as the method employed in FIGURE 6 both methods providing the ability to lower the ends (45,46) the primary ply component (40A) to a location close to the bead cores (26) during the inflation blow-up forming of the finished tire.

It is understood by those of ordinary skill in the art that the method of forming the tire as shown in FIGURES 5 or 6 can be employed on the inventive tire FIGURES 1 and 2 or alternatively the runflat tire FIGURES 3 and 4 without significant modification.

With reference to FIGURES 8 and 9 cross-sectional views of a second and third alternative embodiment tires (10) are shown. In the second embodiment tire (10), the ply extension (40B) of the composite ply (40) is fabricated in a unique manner. As shown, both the radially inner end (33) and the radially outer end (32) of the ply extension (40B) extend a distance approximately under the belt reinforcing structure (36). The ply extension (40B) as shown has a predetermined cross-sectional thickness (T), the ply cords (43) are placed adjacent one surface as opposed to the opposite surface resulting in a asymmetric location of the cords (43) such that a large amount of elastomeric material is on one side of the cords (43) with virtually none on the opposite side of the cords (43).

During the fabrication of this tire, the ply extensions (40B) are laid on the building drum and extend substantially wider on either side of the bead core (26). The width is sufficient so that as the tire is inflated, the ends (32) will terminate under the belts (50, 51). The primary ply (40A) is laid between the bead cores (26) as shown and the overlapping joint (70) is precured by preferably activating an induction heating coil locally to create an induction field between ends (45, 46) and ends (33). Alternatively, the composite ply (40) can be brought to the building drum (5) with the ply extensions (40B) already precured to the primary ply (40A). As the tire

(10) is inflated and the ply extension (40B) is turned up, the tire cross-section results as shown in FIGURE 8. Preferably, the elastomeric ply coat for the ply extension (40B) is similar in composition to the insert fillers (42, 46) previously discussed. As the ply extension (40B) turns up, it forms two insert fillers material and apex filler from the thickened area of the ply coat. The primary ply (40A) is sandwiched and interposed between both ends (32, 33) of the radially extending ply extension (40B), the resultant tire is a runflat tire wherein the apex filler and inserts were cleverly replaced by being incorporated into the ply extension (40B). As can be easily appreciated by those of ordinary skill in the art, this tire greatly reduces the number of components used in the manufacture and assembly of a runflat tire greatly improving both the speed and accuracy at which the tire can be manufactured. The cords (41) of the primary ply preferably are inextensible but could be any of the cord materials described including nylon, rayon, polyester, etc.

If a higher effective tire spring rate is needed the tire of FIGURE 8 may further include inserts (42) located radially inward and adjacent to the ply extension (40B) as shown in FIGURE 9. This third alternative embodiment runflat tire has a great load carrying capacity at O inflation pressure.

When assembling the runflat tire of FIGURE 4 with a composite ply (40), the preferred method includes the steps of providing a building drum (5) having a contoured profile as shown in the cross-sectional view of FIGURES 7A, 7B and 7C applying the liner (35), a toe guard of fabric material (optionally), the first inserts (42) and the ply (38) with synthetic cords overlaying the previously mentioned components. Then the composite ply (40) with the primary ply (40A) precured to the ply extensions (40B) at the joint interfaces (70) is placed over the ply (38) approximately centered at the planes (B-B), the planes (B-B) being the planes defining the spacing (L) between the bead cores (26). Then one bead core (26) is placed at each plane (B-B). It is important to note that the bead cores (26) can slide over the carcass structure without impediment because of the drum contours and the sufficiently large inside diameter of the bead cores (26). This means the cores (26) can freely be slide over the entire structure from either end of the building drum or the beads (26) can be installed from both ends, if desired.

When the beads (26) are installed, the crown drum expands setting the beads location. The insert fillers (46) are then applied. It is important to note that the primary ply (40A) has a width W_A about equal to the bead core spacing (L), then the apex fillers (48) are attached preferably directly over the ends (45,46) of the primary ply (40A). The carcass then has the turnups (34) of the ply (38) and (32) of the extension (40B) folded up and stitched to the carcass. Then belt wedge gums strips and the chafer and sidewall components (60,20) are attached. The carcass is then inflated to a toroidal shape and as the tire (10) is being shaped, the primary ply

(40A) rotates adjacent the bead cores (26) to the axially inner location of the bead cores (26) contiguously fixed at the precured joint (70) to the ply extensions (40B) as previously discussed. Then the belt layers (50, 51) and the overlay (59) (if used) is applied as well as the tread (12), thus completing the assembly of the green tire (10).

In the preferred embodiment tire (10) of FIGURES 3 and 4, the overlay (59) is wound spirally over the belts in three layers to enhance the stiffness of the tread when the tire is operated in the runflat condition.

It will be appreciated by those of ordinary skill in the art the chafing of the tires as shown in the lower bead region radially outward of the carcass structure (30) adjacent the rim flange may be minimized, especially during the use in uninflated condition by providing a hard rubber chafer portion (60). Furthermore, it is appreciated by those of ordinary skill in the art that high-speed performance of the tires shown can be enhanced by the addition of fabric overlays (59), including, but not limited to, nylon or aramid overlays either in fabric plies or in strips.